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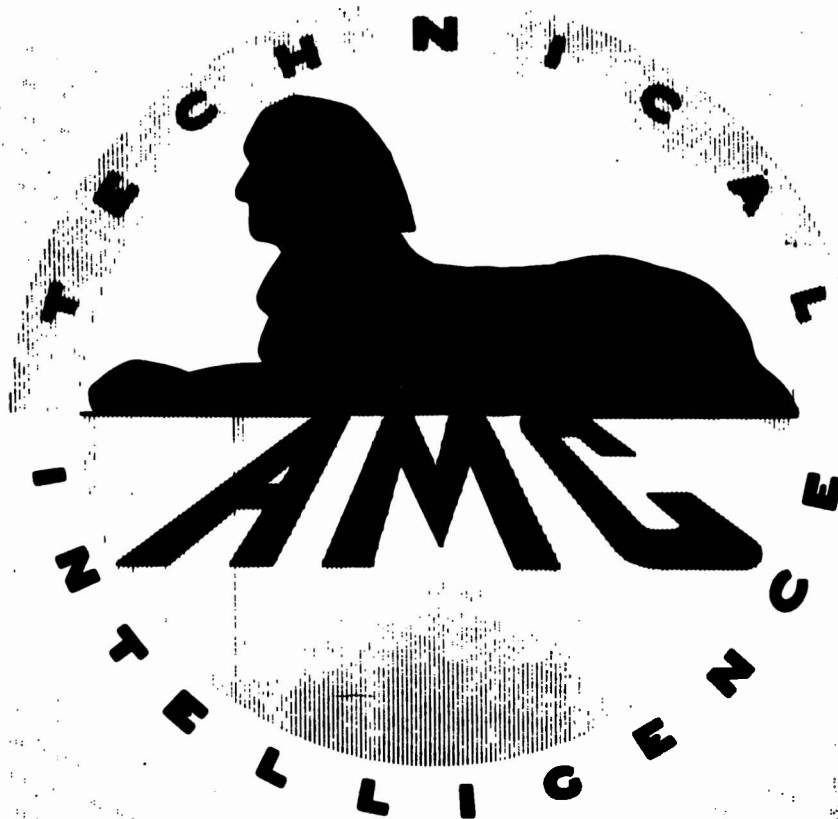
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Report 993-2

August 23, 1944

PRELIMINARY DESIGN
OF AIRBORNE MULTIPLE
SPOT JAMMING SYSTEM

Bell Telephone Laboratories, Inc.

OE-Mer-993

OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT
NATIONAL DEFENSE RESEARCH COMMITTEE
DIVISION OF RADIO COORDINATION (15)

Project RP-122

*Distribution: In accordance
with Schedule "C"*

Title Page
Index Page
3 Drawings
9 Text Pages

by: E. R. TAYLOR

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Report 933-2

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PRELIMINARY DESIGN
OF AIRBORNE
MULTIPLE SPOT JAMMING SYSTEM

1. INTRODUCTION

This report describes an airborne spot jamming system such that one to four AN/ARQ-9 radio transmitters may be operated simultaneously in the same airplane in order to jam a like number of communication channels. Both narrow and broad band monitoring facilities are included. Synchronous control of all transmitters and of the frequency scanners is provided as an aid to the observation of victim signals. The need for a system of this type was pointed out in NDRC Report 966-27 dated April 27, 1944, entitled "Airborne Spot Jamming System Study".

The preliminary design of this system was undertaken in order to shorten the development interval which will be required if the Army decides to order systems of this type. The development has been carried far enough to determine practicable circuit and equipment arrangements. Specific circuit and equipment development work required for quantity production will be carried out as requested by the Armed Forces.

This report describes the proposed arrangements in considerable detail in order that the Services may plan the location of the system and set up requirements for its completion. No consideration is given to the antenna problems involved in multiple operation.

2. SUMMARY

The general features, size, weight etc. of the proposed system may be summarized as follows:

2.1 General Features

- (a) From one to four radio transmitters may be operated simultaneously in the same plane in order to jam a like number of individual communication channels.
- (b) All the transmitters in the plane operate on the same jam-scan cycle in order to minimize interference during the "look through" intervals.

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- 2 -

- (c) A broad band scanner affords panoramic representation of the radio signals in the 18 to 80 mc band or in any 8 mc thereof. Indications of jammer and victim signals alternate in quick succession.
- (d) A single set of narrow band aural and visual receivers is provided for detailed monitoring of each victim and jammer in turn.
- (e) Controls are provided such that each transmitter individually may be turned on or off or caused to produce a marker signal for use with the broad band scanner in identifying a signal appearing thereon or in rapidly tuning the jammer to such a signal.
- (f) Each radio transmitter is designed to work with a 50 ohm antenna individual to it, with the exception that one of the antennas will be used alternately with the broad band scanner.
- (g) The system is designed for normal operation with an automatic cycle synchronizing the turning on and off of the transmitters and scanning cycles but manual control of the transmit-receive cycle of all transmitters may be used if desired.
- (h) The automatic cycle is nominally seven thirty-seconds of a second transmit and one thirty-second of a second receive, repeated continuously.
- (i) All of the major equipment units, composing the system are standard AN/ARQ-9 design used without modification.

2.2 Size

12 SARC units are required. Their sizes are indicated by the following designations:

- 1 #AIC*
- 2 #AID
- 3 #BID
- 1 #CID
- 5 #CED

Miscellaneous small units include four thermocouple units and five multiple boxes.*

* Preliminary design special for this system.

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2.3 Weight

The weight of the entire system is estimated to be 700 pounds. This does not include antennas or power plants for producing and regulating 28 volt d-c or 115 volt a-c.

2.4 Power Required

The estimated power drains for the complete system are: 3,000 volt-amperes of 115 volt 400 to 2400 cycle a-c and 10 amperes of 28 volt d-c.

3. CIRCUIT ARRANGEMENTS

The complete multiple spot jamming system is shown in block diagram form on Dwg. ES-832794. The six blocks near the left hand side of the drawing represent the major units of a normal AN/ARQ-9 System for jamming a single channel. These units are used in the normal manner except that certain of the interconnecting cables are routed through multiple or control blocks designed especially for this multiple system. The other three transmitters and the two rectifier power units are also normal AN/ARQ-9 design. Detailed circuits for the control box and the multiples are shown on Dwg. ES-833427.

The following subsections discuss the purposes of the new units and the proposed circuits.

3.1 Transmitter Control Multiple

The enabling and disabling control leads for the transmitter are normally cabled directly from jack 2 on the scanner to jack 31 on the transmitter. In the multiple system these leads are cabled from the scanner to jack S on the control unit where they are multipled or switched to the four transmitters in order to afford either synchronous or individual control of them. The leads for all four transmitters pass through jack C0 and then are separated at the Control Multiple in order to reduce the number of jacks on the control unit.

As shown on ES-833427, the TRANS BLK leads pass through switches (TRANS CONT) individual to the transmitters so that the low level transmitting stages may be either under control of the scanner or individually blocked. The double diode TRANS BLK LEAD IMP CONT minimizes interaction between transmitters via the TRANS BLK leads by forming a low impedance path for grid currents.

The PWR STG BLK leads also pass through these switches so that the transmitter power stages may be either under control of the scanner or individually blocked.

The M.T. BLK lead passes through a four position switch (TRANS SEL) in such a manner that the receiving stages of all transmitters except one are blocked. The exception is under the control of the scanner. In short the TRANS SEL switch determines the transmitter which is connected to the narrow band aural and visual receivers.

The T-R REL CONT provides for the operation of the T-R relay in the transmitter selected by TRANS SEL and for the one in the transmitter sharing an antenna with the broad band scanner.

3.2 Modulator Output Multiple

The modulated intermediate frequency for driving the transmitter is normally obtained directly from the modulator under the control of the scanner. In the multiple system the modulator output is connected through Jack M to an amplifier in the control unit. The output of this amplifier passes through Jack T to the MOD OUT MULT which contains a five-way impedance matching pad so that the inputs of all four transmitters may be obtained from one source. The function of the amplifier is to make up for the loss in the five-way pad.

3.3 Monitor Tuner Output Multiple

Each monitor tuner output (jack 24) instead of going directly to the receiver (jack 8) goes through another five-way impedance matching pad in the MT OUT MULT to Jack MT and an amplifier in the control unit and on thru Jack R to the receiver.

A blocking voltage is applied to the central conductor of Jack MT and hence to the AVC lead of each monitor tuner in order to prevent cross talk between monitor tuners if one or more is inadvertently operated to AVC rather than Manual Sensitivity.

3.4 Marker Multiple

The marker outputs (jack 23) of the transmitters are combined in the five-way impedance matching pad of the marker multiple and connected to Jack 34 of the broad band scanner so that the markers of all operating transmitters may be scanned simultaneously.

3.5 Power Multiple

Power for the second transmitter and for the vacuum tubes in the control unit is obtained from a second PP-55/ARQ-9 Rectifier Power Unit. Power for the third and fourth transmitters is obtained from a third unit of the same type. These power units, the fourth transmitter and the control unit are interconnected by the power multiple in order to reduce the number of jacks required in the control unit.

The power circuits shown for the control unit are conventional with the exceptions that a VR tube circuit is added to furnish +150 volt supply to the fourth transmitter. A relay, with resistances simulating a part of a transmitter's drain is added to automatically stabilize the load on the third rectifier power unit if the fourth transmitter is omitted.

4. EQUIPMENT CONSIDERATIONS

Multiple jamming poses a difficult equipment location problem which is largely contingent on the space that may be made available in the planes and on the service requirements which may be established for the location of the large numbers of jacks and cables inherent to a multiple system.

In the preliminary design described in this report, the location of external connections to units containing controls or vacuum tubes is limited to along the two sides and bottom of the front panel. This is in accordance with ARL requirements on other AN/ARQ-9 Units. It is also assumed that control mounting space within easy reach of the operator will be at a premium. Accordingly the size of the control unit has been held to a minimum at the expense of a few additional cables and five small multiple units.

If the requirements on the location of connectors were changed to permit location along the sides of the unit the additional cables and separate multiple units could be avoided.

The complete system including interconnecting cables is shown on ES-827909. Suggestions regarding the location of each of the major units are given below.

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4.1 Standard AN/ARQ-9 Units

(a) Scanner Unit (ID-47/ARQ-9)

This unit contains the master controls and the cathode ray tube used for the indications from both narrow band and wide band scanners. The cathode ray tube is observed continuously during operation, so this unit should be centrally located at a convenient eye level for the operator. This is an SARC Unit designated C2D.

(b) Four Radio Transmitters - (T-44, 45 or 46/ARQ-9)

Each of these includes tuning controls as well as dials and meters. The tuning must be adjusted while the operator is watching the cathode ray tube in the scanner, so all four transmitters should be located within easy reach of the operator when he is seated before the scanner. The transmitter dials should be at reasonable eye level because the preliminary tuning is done by dial rather than scanner indication. Each transmitter is an SARC unit designated C2D.

(c) Receiver - Indicator (R-102/ARQ-9)

This is the broad band scanner. It includes sensitivity and tuning controls which require occasional readjustment while the operator is watching the cathode ray tube in the scanner. Accordingly, the receiver-indicator should be located within easy reach of the operator but not necessarily at optimum eye level. It is an SARC unit designated C1D.

(d) Three Rectifier Power Units (PP-55/ARQ-9)

Each includes an on-off switch and a tap changing switch which is adjusted infrequently while the operator is observing a meter on an associated transmitter. Accordingly each power unit should be within reach of the operator when he is standing before the transmitter it supplies. Each rectifier power unit is an SARC unit designated B1D.

(e) Modulator (MD-15/ARQ-9)

Normally this unit will not require attention during a multiple jamming mission so it may be located anywhere within reasonable cable length of the other equipment. The modulator is an SARC unit designated A1D.

SECRET(r) Radio Receiver (R-55/ARQ-9)

Normally this unit also will not require attention during multiple jamming and may be located anywhere within reasonable cable length of the other equipment. It is an SARC unit designated ALD.

4.2 Units Special to the Multiple Jamming System(a) Control Unit

This unit includes four three-position keys and a rotary switch which will require frequent adjustment during a jamming mission. The unit should be located within easy reach of the operator but not necessarily at eye level. It is expected to be no larger than an ALC SARC unit.

(b) Multiple Units

Each of the five multiple units consists of little more than five cable receptacles and interconnecting wiring in a metal box. It is assumed that they may be bolted to the shelves supporting the other equipment units or mounted in some other out-of-the-way place that conserves "front panel" space.

5. OPERATION

This system is designed for the method of operation and the tactical problem discussed in detail in section 5 of NDRC Report 966-27. However, it is recognized that other tactical problems needing systems of this general type exist and that the operating method of each must eventually be evolved in the field. Accordingly a considerable amount of flexibility has been built into the system where possible without increase in weight or complexity. The following paragraphs illustrate the types of operation changes that may be found desirable:

- (a) The operator of four transmitters will be very busy and may not be able to keep the frequency of each victim matched sufficiently well for the usual noise band width to be completely effective. If such a condition arises the band width may be set to a suitable value by a simple change in the lineup procedure of the modulator unit.

SECRET

(b) The minimum band width scanned by the standard broad band scanner is 8 mc. Situations may arise where the band of interest is much narrower and maximum scanning resolution is desired. This condition may be met by giving a special mechanical adjustment to the motor driven condenser in the scanning oscillator. The minimum band width would then be about 5 mc but the maximum would be unchanged.

(c) Tactical problems may arise which require simultaneous jamming of frequencies widely scattered in the 18 to 80 mc band. This situation and the similar one where the entire 18 to 80 mc band is to be searched, may be handled by specifying one transmitter for each of the three subdivisions, 18 to 34 mc, 30 to 52 mc and 50 to 80 mc. This would result in all the operating features afforded by the more usual case where all four transmitters are for the same band, except that the broad band scanner would necessarily afford poorer resolution when scanning the entire 18 to 80 mc band. Of course, the better resolution of an 8 mc scan could be had if conditions are such that rapid switching of the broad band scanner from one sub-band to another is permissible.

3.1 Frequency Separation Required Between Monitoring and Unsynchronized Jamming

Preproduction models (SCR-596-T2) of transmitter, receiver, scanner and broad band scanner were tested to determine the frequency separation between jammer and other stations necessary for aural or visual monitoring. These tests were made at 40 mc with a 7 kc jammer band width. The jammer was delivering a half a volt signal to the input of the monitoring equipment. The following table gives the indicated minimum allowable separations:

Monitored Signal Strength in microvolts	Freq. separations required for			
	Aural Reception	Narrow Band Scanning	8 mc Scanning	18-80 mc Scanning
50,000	8 kc	9 kc	100 kc	250 kc
10,000	14 kc	10 kc	100 kc	250 kc
1,000	23 kc	14 kc	100 kc	250 kc
100	38 kc	27 kc	100 kc	250 kc

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5.2 Method of Distinguishing Between Local Transmitter Markers and Other Signals

Broad band scanner markers indicating the frequencies of the transmitters in the same plane as the scanner appear as the same type of pips as those produced by external stations. The marker pips appear twelve times each second and the station pips appear only two or four times a second. Accordingly the station pips seem to be fainter and are easily distinguished from the marker pips.

6. FUTURE WORK

The immediate objective has been reached as discussed above but a considerable amount of additional work should be considered if the Armed Forces plan any large use of such a system. One of the first things that should be done upon resumption of work, is obtaining requirements for and agreement on the specific equipment arrangements desired. This would be followed by the usual preparation of manufacturing information instruction manual etc. which are beyond the scope of the present project.

Other development work which should then be considered includes setting up a complete four transmitter system in the laboratory and jamming several simulated communication links in order to determine whether the indications, controls etc. are adequate for single operator control of four transmitters.

Flight tests of a complete system jamming simulated enemy channels at least one of which was airborne would be of great assistance. They would also afford opportunity for measurement of the interaction between the various antennas and the receivers in the same or nearby planes and hence of the selectivity and resolution required to prevent one enemy channel from hiding in the shadow of another that is being jammed.

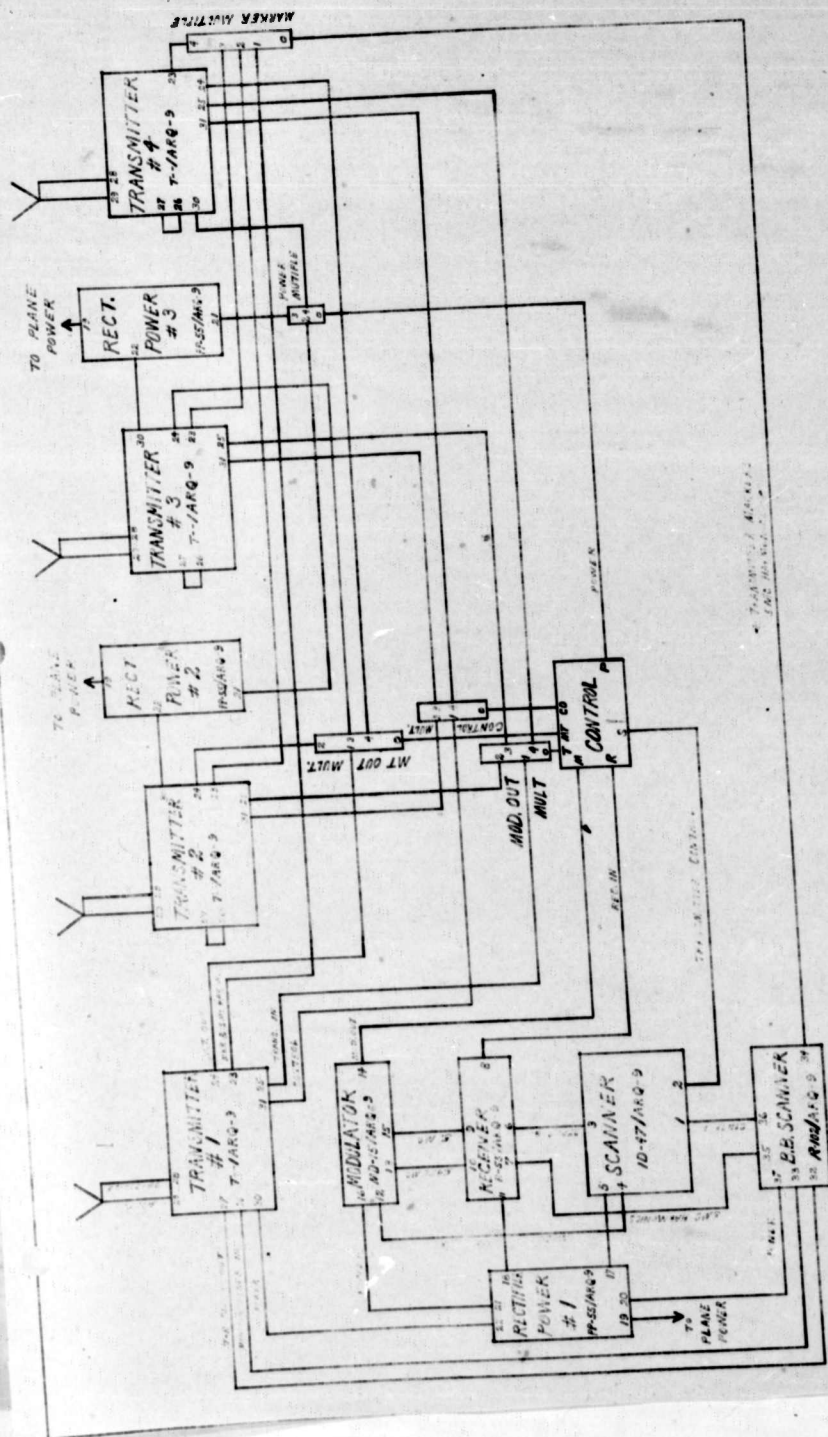
Consideration should also be given to detailed transmission tests of production AN/ARQ-9 Units to determine selectivity, overload and resolution characteristics over a wide range of input conditions. These data would be helpful in setting up operating procedures that are likely to meet field conditions.

E. R. TAYLOR

Attached:

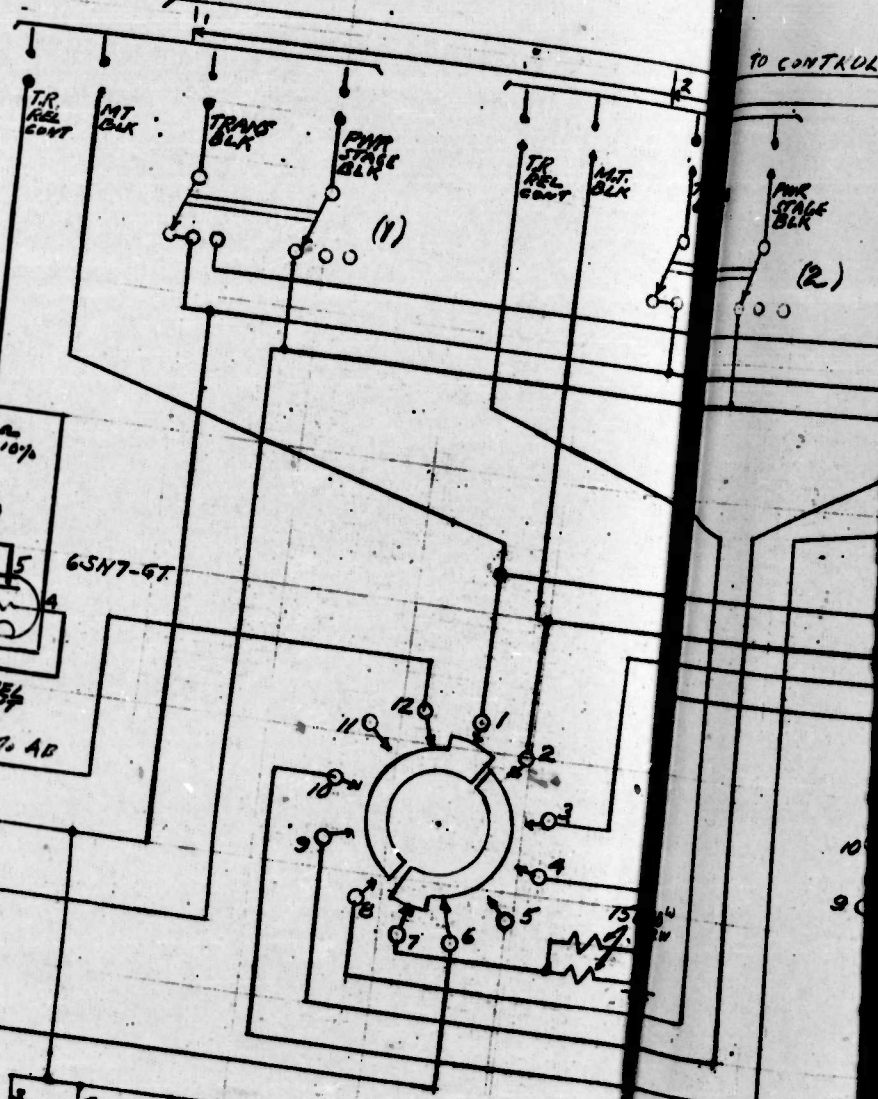
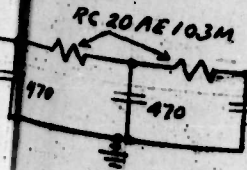
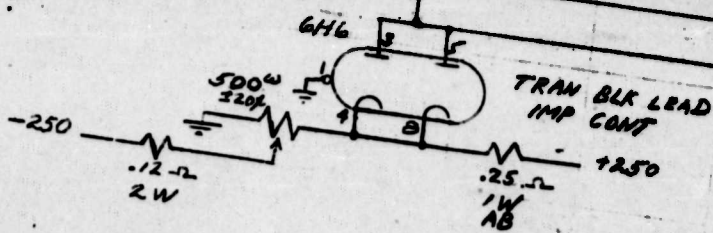
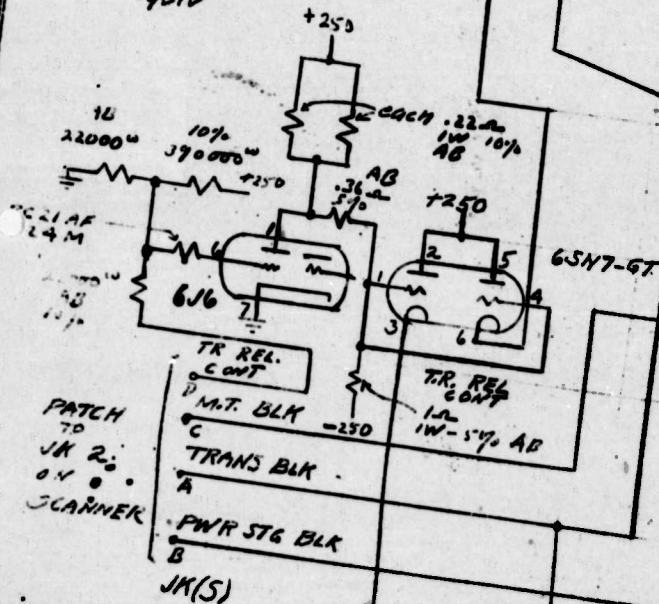
Drawings - ES-832794
ES-833427
ES-827909

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AN/ARQ-9
PROPOSED
MULTIPLE OPERATING
OF
1 TO 4 TRANSMITTERS
1 MODULATOR/RECEIVER
1 MARKER BAND SCANNER
1 BAND BAND SCANNER
SECRET
ES-83274

**TRANS
CONT**
4 separate
controls
Centralab 1466
or equiv



CONTROL CKT.

TO CONTROL MULT.

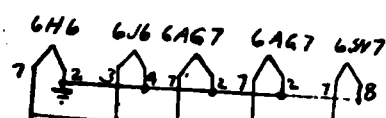
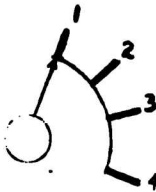
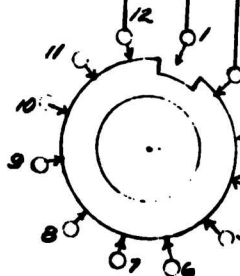
ALL IN ONE CABLE

JACK (CO)

(2)

(3)

(4)



MOD AMP
6AG7

D166245 NETWORK

CC21CH060D B

D166245 NETWORK

CN55A103

D166245 NET.

RC20AE 103M

1250

RC 30AE33M

RC 20AE103T

1250

RC 30AE271M

(T)

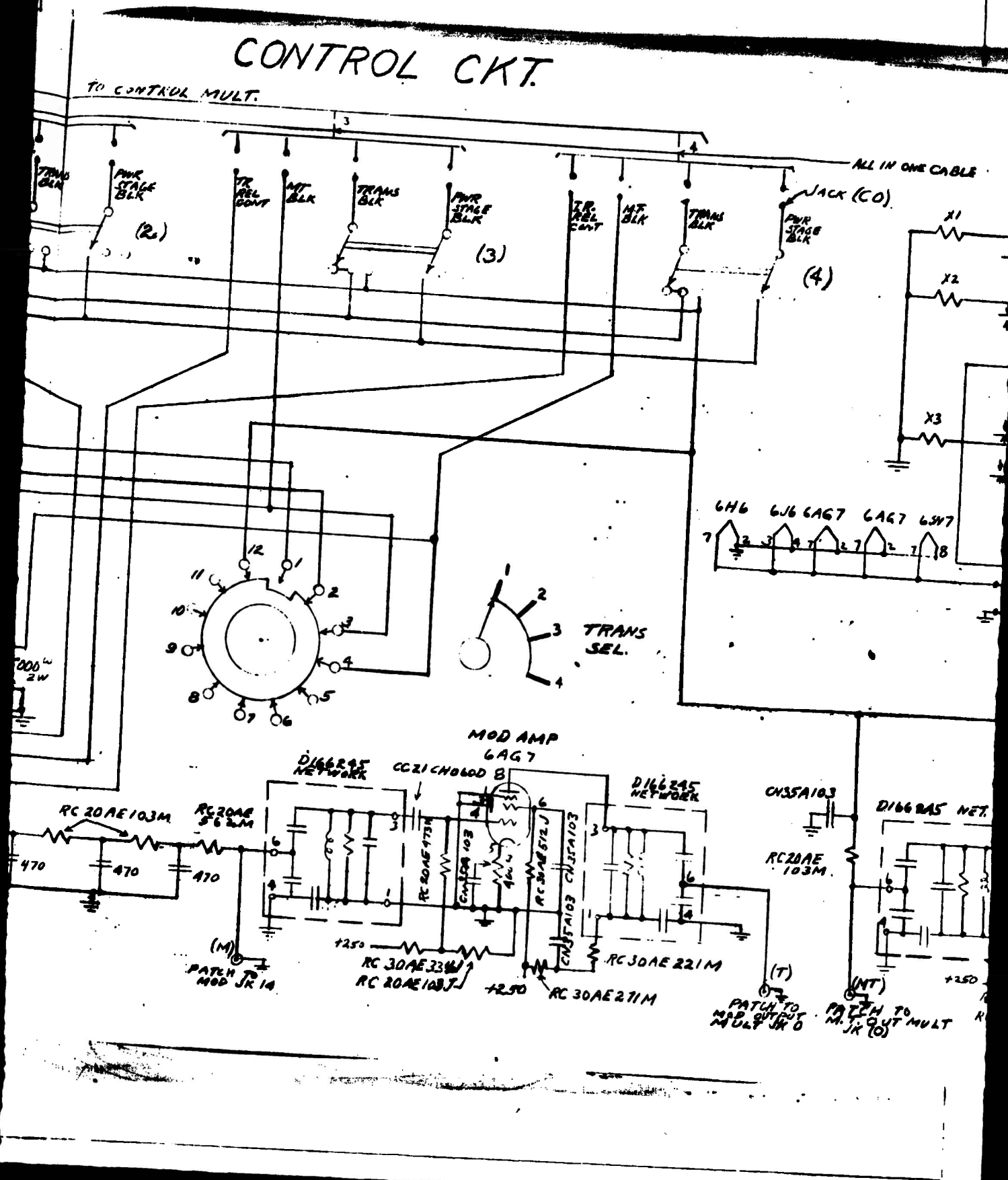
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MOD OUTPUT
MULT JK 0

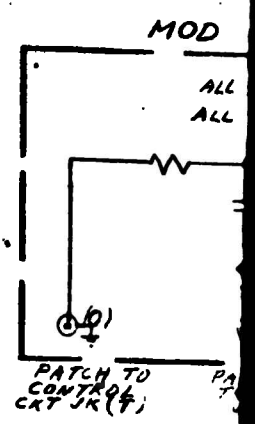
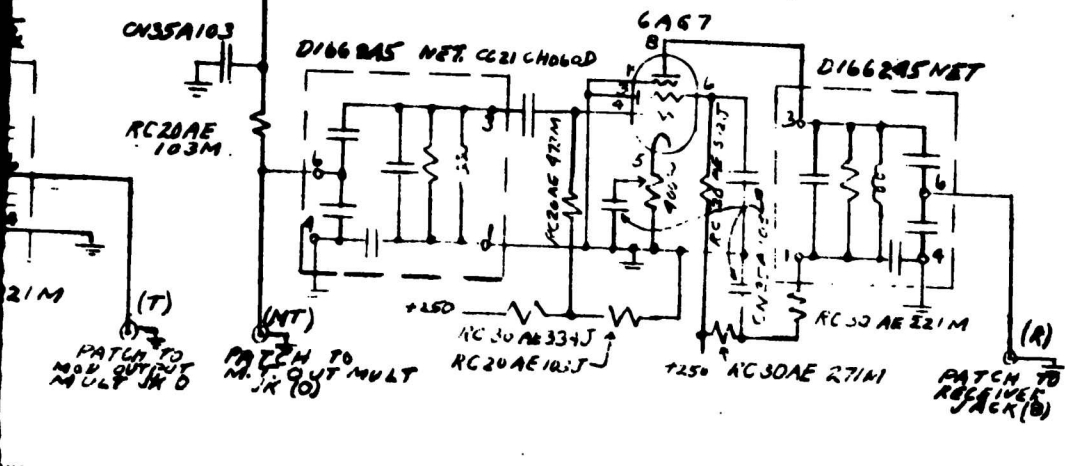
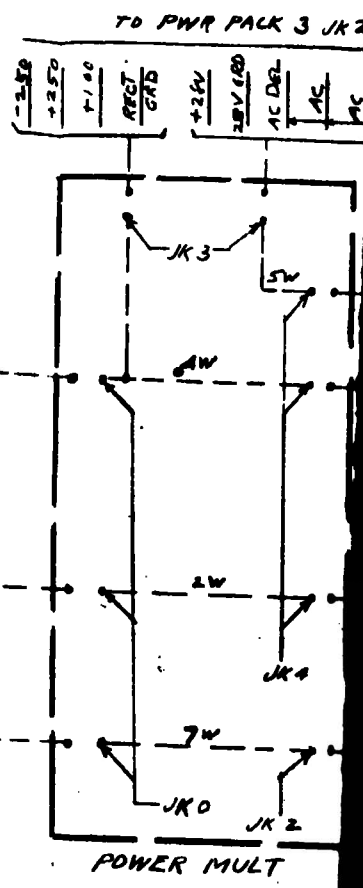
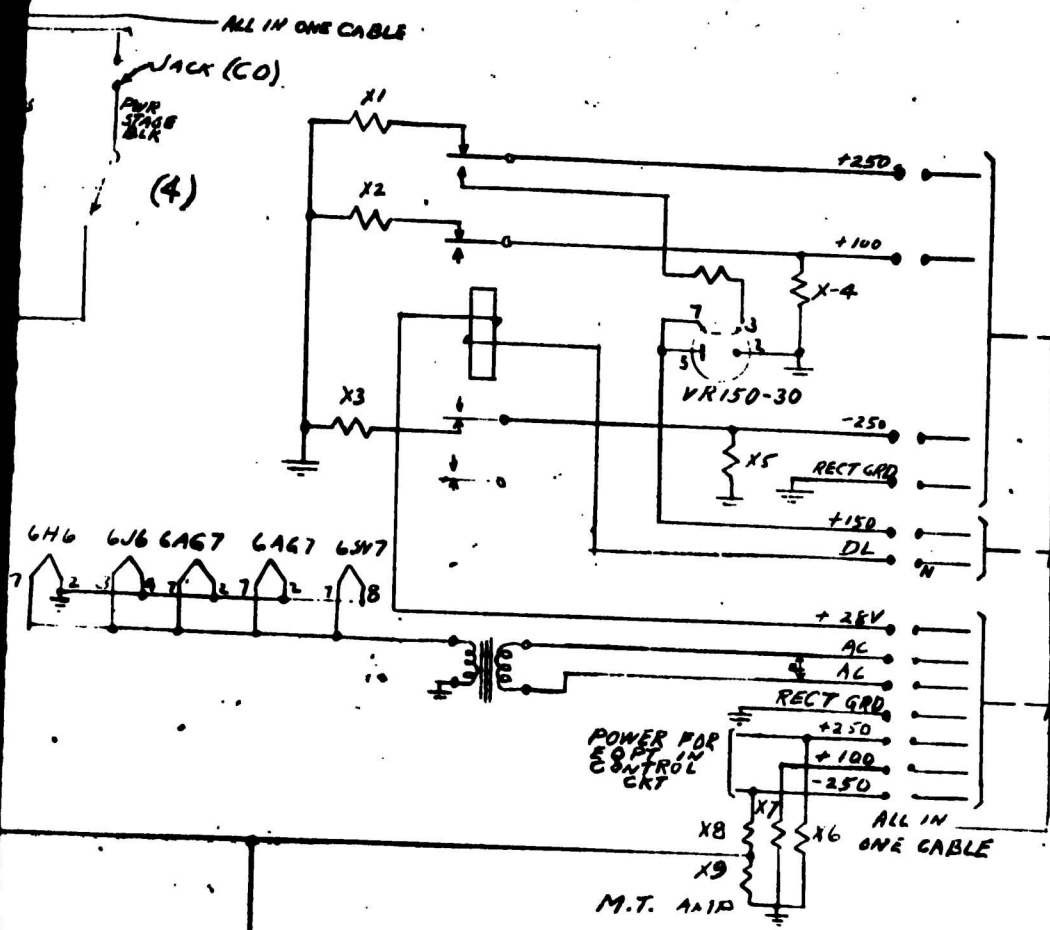
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PATCH TO
MOD OUTPUT
MULT JK (0)

(M)

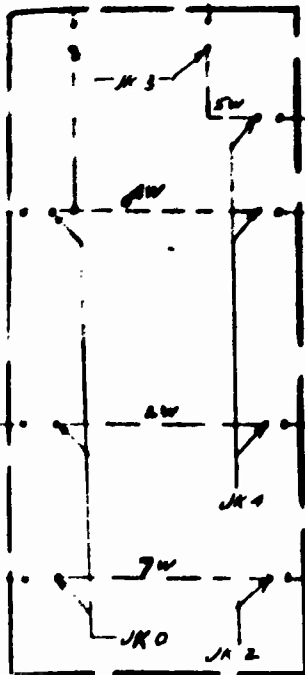
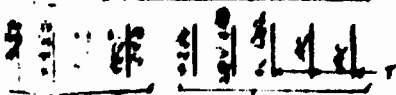
PATCH TO
MOD JK 14





MULTIFLES

TO PWR PALK 3 JK 21



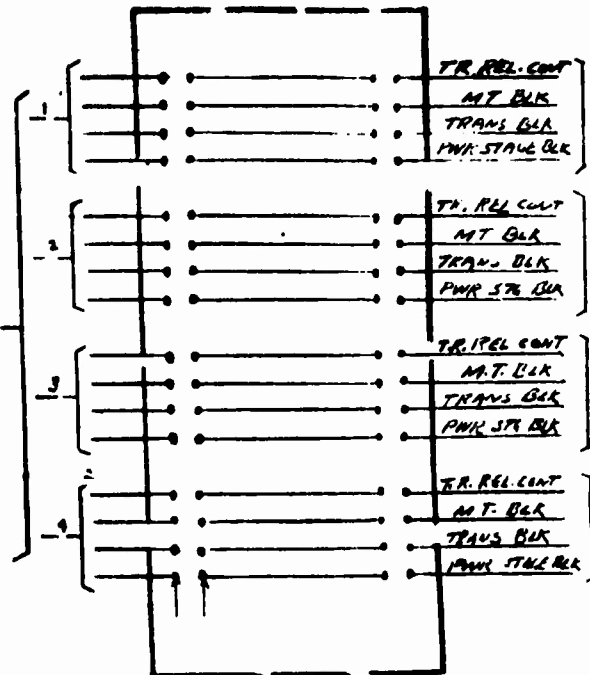
POWER MULT

TO TRANS
#4
JK 30

TO CONTROL
JK 10

ALL IN
ONE CABLE

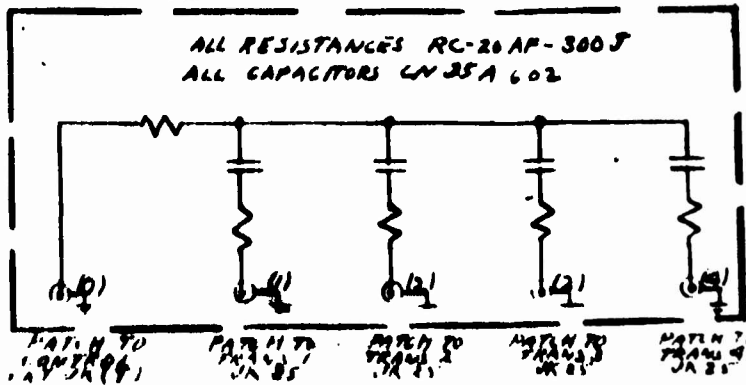
TO PWR PALK 3 JK 21



CONTROL MULT.

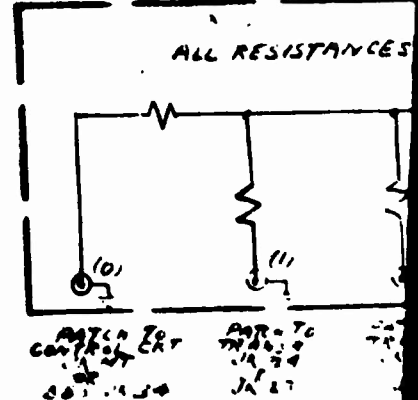
MOD OUTPUT MULT

ALL RESISTANCES RC-20 AF-300 J
ALL CAPACITORS CN 25A 602



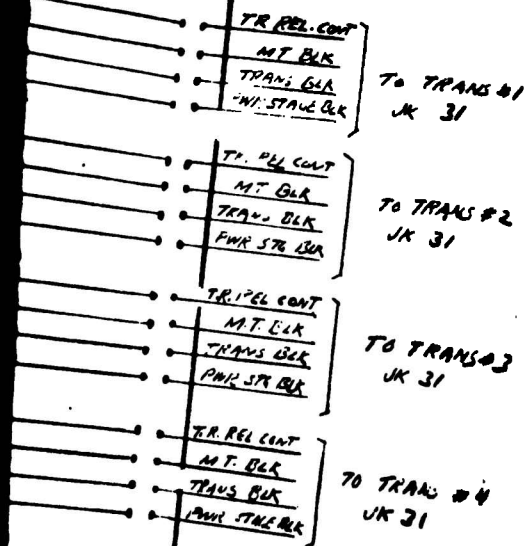
M.T. OUT M
OR
MKR MULT

ALL RESISTANCES



MULTIPLES

ISS	DATE	EXCH
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2	6/14/44	TLD
3	8/5/44	TLD

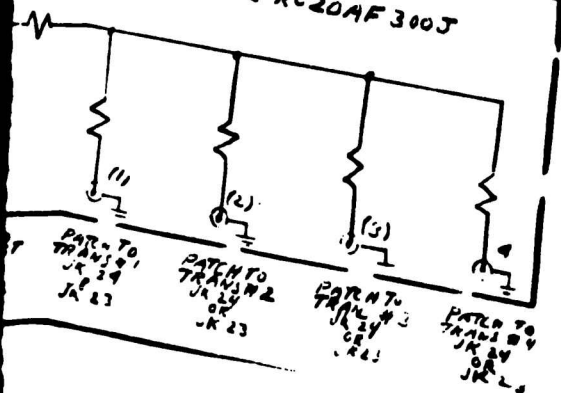


1. All resistances must be Allen Bradley
2. Resistors are wire wound ceramic type
3. Shorting contacts shall be used TRANS SEL and TRANS CONT SWITCHES.

DL MULT.

M.T. OUT MULT
OR
MKR MULT.

ALL RESISTANCES RC20AF300J

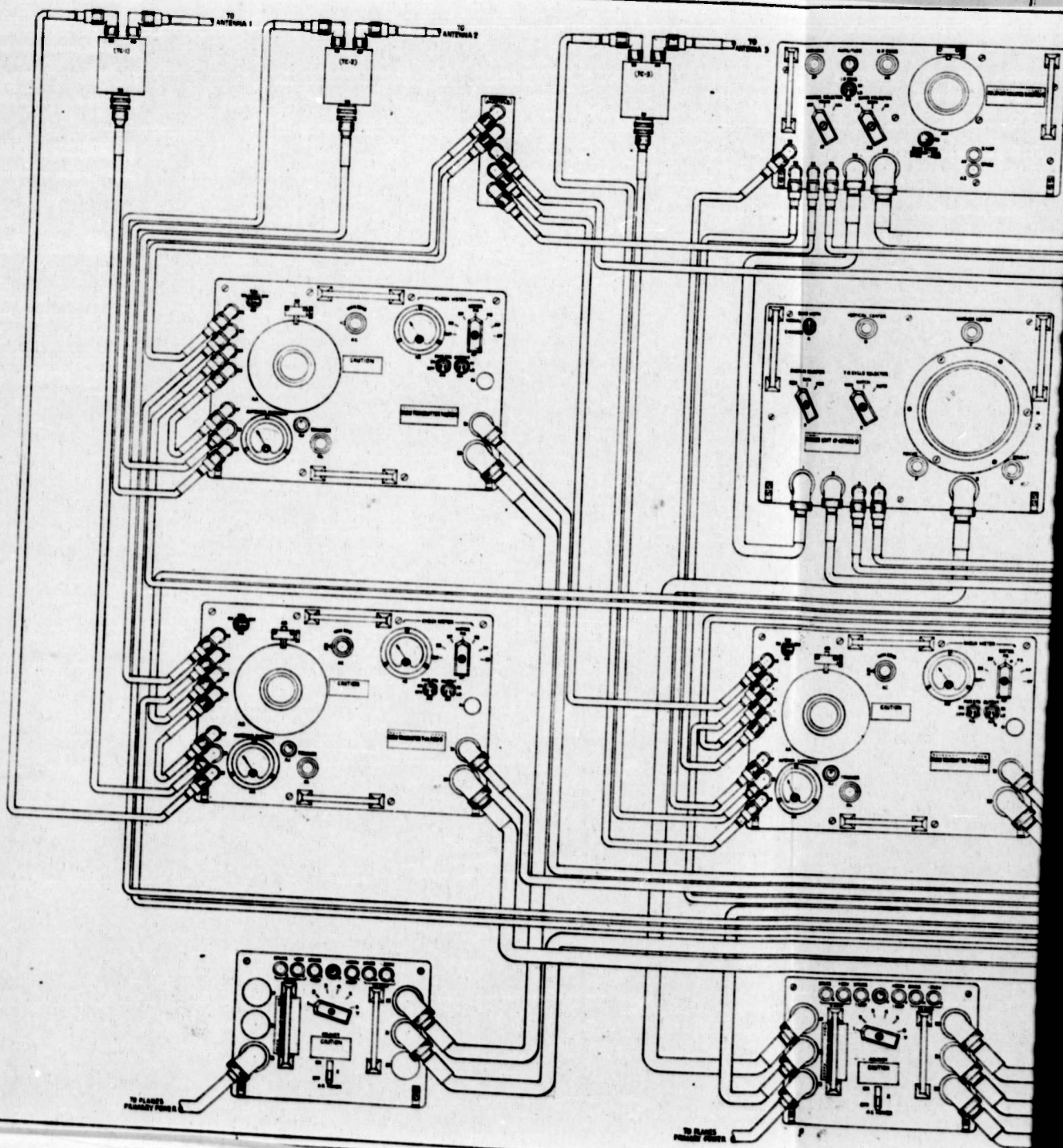


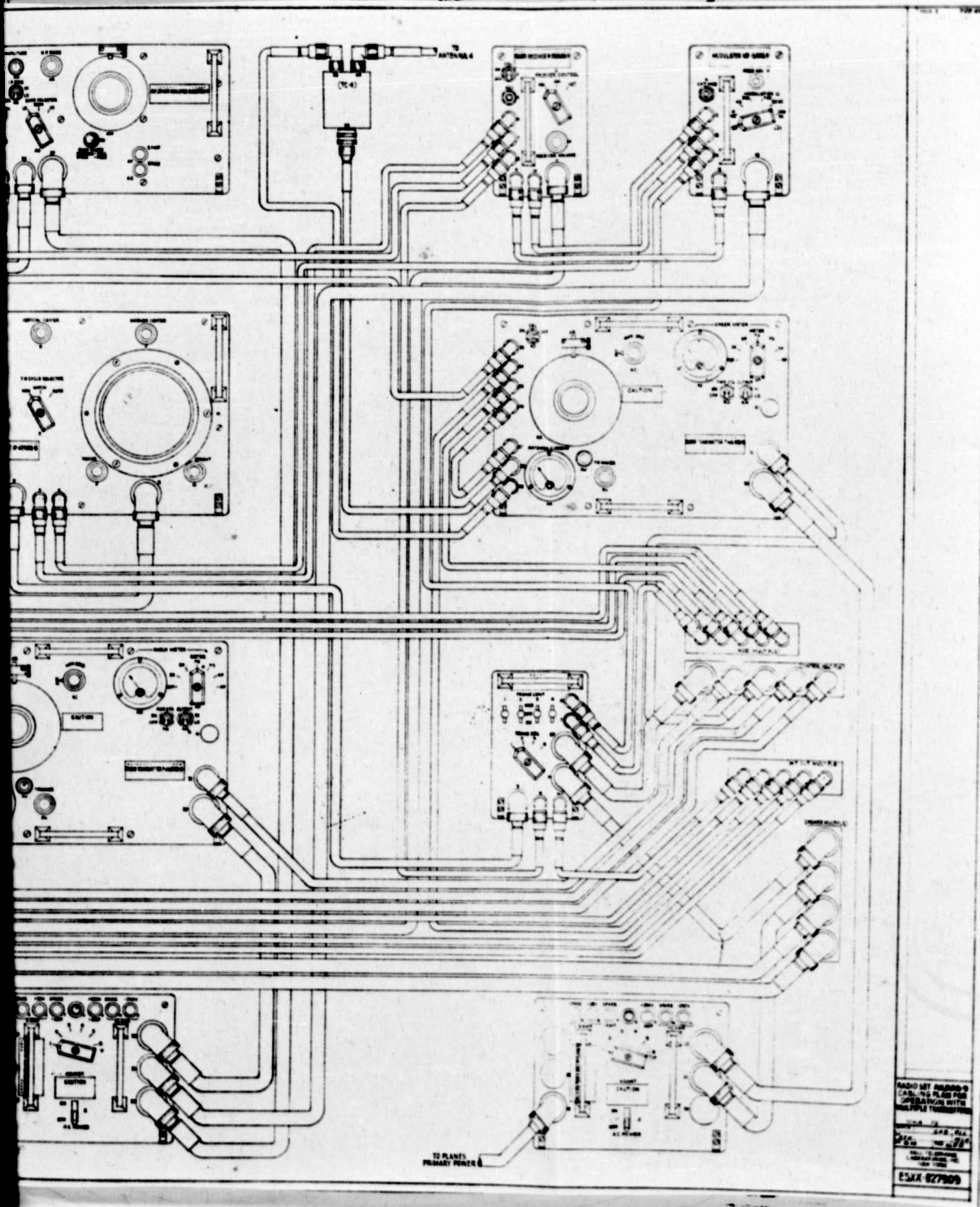
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ES833427

AN/ATQ-9

CIRCUITS FOR
PROPOSED
MULTIPLE OPERATION





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A.T.I.

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ABSTRACT

Design of a system with which one to four AN/ARQ-9 radio transmitters may be operated simultaneously in same airplane in order to jam a like number of communication channels is described. Both narrow and broad band monitoring facilities are included. Development was carried far enough to determine practicable circuit and equipment arrangements. Report describes proposed arrangements in considerable detail. General features, size, weight, etc., of this proposed system are given.

NTIS auth: SOD memo, 2 Aug 60
AD-A800 188

INDEX

WRIGHT FIELD, OHIO, USAAF

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or changed to

OSRD List No. R-1 Dated Nov 1, 45 -

AUTH:

By

John E. Moore *WFO*

Signature and Grade

APR. 26, 1946

Date

27 November 1951

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EO 10501 dd, 5 NOV 1953